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**Facultative Cessions and Per-Risk Treaties**

Functional Specifications

|  |  |
| --- | --- |
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# Problem Statement

Compute payout for the facultative cessions and per-risk treaties defined at different Contract levels.

# Expressing Per-Risk Contracts Using Contract Model

**See CDL\_03\_CATReinsurance.docx.**

## Covers and Filters:

### Per-risk treaties:

* One parent Cover that contains per occurrence limit specification, i.e. attachment = 0 and Limit = Occurrence Limit
* Children Covers:
  + For Surplus Share each Cover’s subject will be one Contract to the further subject(s) of which the Surplus Share is applied. If Surplus Share applies on the Contract level Attachment and Limit will be specified for each Cover. If Surplus Share applies on a more granular level, each child caver will have a set of child covers with specified attachments, limits and Shares

### Facultative Cession

* No Children covers
* May be several Parent Covers
  + Subject of each Cover is the Contract.Filter. Where Contract is the Contract to whose subject (Filter) the Facultative cession is applied

# Assumptions

1. The whole Reinsurance program is known.
2. All Inuring levels are known explicitly.
3. No overlap in the term trees, i.e. each node, consisting of some number of terms that share the same subject, has one and only one parent node.
4. No Cover trees for primary Contracts.
5. Facultative cession (FAC) and per-risk treaty (Treaty) could attach at location (S@R), policy (Cover), account (Contract) level.
6. No regional FAC/Treaty or FAC/Treaty on RItE.
7. FAC or Treaties at different aggregation levels could not have the same inuring priority. The same Treaty cannot attach at different aggregation levels.
8. For current document assume that either all Covers have all Contract exposures as their children (all policies are blanket policies) OR there are non-overlapping restricted policy, considering blanket policy as restricted policy covering all S@Rs

# Levels

The FAC or Per-Risk Treaty could be applied at three levels:

* S@R (location)
* Individual Cover (RiskLink policy layer)
* Contract = Total payout from all Covers (RiskLink account)

# Algorithm

## Notations

**= S@R recoverable**

**= Payout (remaining after application of earlier FACs/Treaties) for Cover *p***

**= Allocated payout for S@R *l***

**= loss for treaty *t* between and for each location *l* with non zero**

**= the cumulative treaty loss for the layer between 0 and**

**= cumulative net of reinsurance loss for S@R *l* and layer between 0 and**

**= cumulative total reinsurance loss for S@R *l* and layer between 0 and**

**=total layer reinsurance loss for S@R *l* layer *i***

**= cumulative treaty *t* loss for the layer between and**

**= treaty *t* loss for S@R *l***

**= total reinsurance loss for S@R *l***

**= treaty *t* loss for layer *i***

**= portion of the Cover *p* reinsurance coming from S@R *l* layer *i***

***=* Cover *p* reinsurance within layer *i***

**= total reinsurance loss for Cover p**

**= set of Covers with**

**= set of locations with**

**= attachment point of treaty *t* for S@R *l*  or for Cover *l***

**= layer height of treaty *t* for S@R *l* or for Cover *l***

***=* percent share for treaty *t* for S@R *l* or for Cover *l***

**= treaty *t* loss for current Contract**

**= total Contract reinsurance loss from the whole program**

## Computations

1. Create the following Table 1

|  |  |
| --- | --- |
| Inuring priority | Aggregation Level |
| b | S@R |
| c | S@R |
| ….. |  |
| a | Cover |
| d | Cover |
| e | Contract |

**Table 1**

1. Sort Table 1 first by “Inuring priority” and second by “Aggregation Level”. Add the third column and create index specific to aggregation level.

|  |  |  |
| --- | --- | --- |
| Inuring priority | Aggregation Level | Index |
| a | Cover | 1 |
| b | S@R | 2 |
| c | S@R | 2 |
| d | Cover | 3 |
| e | Contract | 4 |

**Table 2**

1. Perform optimization by “Index” starting from the lower one.

***FOR*** (index from 1 to #Indices) ***DO***

***IF*** (Index corresponds to S@R and there is a Cover specific RE with higher Index value and there is more than one Cover, covering the same set of children nodes of a term tree) ***THEN***

**Step 1. Term ordering**

**Using S@R recoverable (remaining) compute total reinsurance loss () from all treaties with Index = index (do not take into account Occurrence Limits) and order S@Rs in descending order according to such computed . If some S@R’s have the same then order, say in descending order of and then in ascending order of S@R IDs (if necessary).**

**Step 2. Distribution of the Cover Payout to S@R’s**

**Allocate the total remaining (net) Cover** payout loss coming from the Covers *1,2,…,P,* which are the parents of the S@Rs subject to the treaty

to S@R’s starting from the first S@R from the ordered list. Define The allocated loss should not exceed the **. Maybe just take .**

Denote allocated S@R payout for S@R *l* as**.**

**Need to account for restrictions coming from the different nodes in a term tree. Approaches below work under the assumption # 8 , i.e. either all Covers have all Contract exposures as their children (all policies are blanket policies) OR there are non-overlapping restricted policy, considering blanket policy as restricted policy covering all S@Rs**

**Approach 1**

**Allocate Contract payout in the order in which S@R where organized based on the computed reinsurance. Each time deplete all parents of the given S@R by the allocated amount. Do not allocate further to the children if no payout is remaining.**

**Assume that S@R are in a specified order, i.e. for any )**

**Let is a set of all parents (in the term tree) of the S@R and let be the running recoverable of the of the Parent of the S@R .**

***FOR* ( every S@R *l*) *DO***

***(*Allocated Contract (or part of the Contract) payout to S@R l))**

***FOR* () *DO***

***ENDO p***

***ENDO l***

**Approach 2**

**For each node order direct children nodes in descending order of the total RE loss from all S@R’s covered by the child and allocate recoverable in this order, making sure that allocated loss doesn’t exceed recoverable of the child computed on the way up the tree. (Max Deductible?).**

**Step 3. Layering of the Covers.**

**For each Cover *p* denote attachment point as and** attachment point+as **.**

**For all *p* =*1, 2,…,P* sort and in ascending order. Denote the new bounds as, where +1 and is the resulting number of layers.**

**For Cover *p* such that and**

**Denote**

**payout loss belonging to layer *i* and let total layer payout .**

**Here sum is over all Covers such that**

**and.**

**Also let**

**be the height of .**

**the Cover**

Cover 1

Cover 3

Cover 2

Bound2

Bound3

Bound4

Bound1

ContractLayer2er1

ContractLayer3er1

ContractLayer1er1

Bound6

Bound5

ContractLayer4er1

ContractLayer5er1

**Fig.1 Grey box is a recoverable from the term tree root node, orange boxes are Covers**

**of a Contract.**

**Step 4. Translating allocated Cover layers to S@Rs.**

Align recoverables of the S@R’s**. Translate Cover payout layers from Step 3 to S@R level as follows.**

**For each let**

**and**

**and**

***FOR* ( *i from 1 to NumLayers*) *DO***

***j=1***

1. ***For each S@R l with covered by one of the Covers p with compute***

***Where***

***,***

***is a set of Covers with non zero payout in layer i covering S@R l and***

***is the number of S@Rs with non zero remaining non translated payout covered by Cover p.***

***IF() THEN***

***ENDIF***

1. ***IF( ) THEN***

***.***

***Go to Step 5 to compute reinsurance loss for the layer and then Go To 10***

***ELSE (determine sub layers of the account layer i)***

***j = j+1***

***Go to 1***

***ENDIF***

**10. End *i***

**Step 5. Compute Reinsurance Loss.**

For each  **compute reinsurance loss as follows.**

***FOR*(i from 1 to NumLayers) *DO***

***FOR* ( every S@R *l*) *DO***

***END l***

***FOR* (*r* from 1 to ) *DO (inuring priority loop)***

***FOR* ( every S@R *l*) *DO***

***END l***

***FOR* (*t* from 1 to) *DO (treaty loop for inuring level r)***

***FOR* ( every S@R *l*) *DO***

***END l***

***,* hereis a set off all S@R’s from all Contracts covered by treaty *t***

***FOR* (for every S@R *l*) *DO***

***( layer i computations)***

***IF (i=1) THEN***

***ELSE***

***ENDIF***

***END l (end S@R loop)***

***IF (i=1) THEN***

***ELSE***

***ENDIF***

***END t (end treaty loop)***

***END r (end inuring priority loop)***

***FOR*( *p in* ) *(Cover loop)***

***END p***

***END i (end layer loop)***

**Step 6. Update Cover Payout and S@R recoverable (formerly known as Gross Loss)**

***FOR*( *p in1,…, P*)  *DO***

***END p***

**Update S@R recoverable (formerly known as Gross Loss)**

***FOR* (every S@R *l*) *DO***

***END l***

**Also may need to update all intermediate nodes of the term tree by aggregating from nodes children and netting that out of the recoverable for that node. This will be desirable if there is a location level treaty with inuring priority higher then that of the Cover level treaty.**

***FOR* (every S@R *l*) *DO (total contract RE loss)***

***END l***

***ELSE IF*** (Index corresponds to S@R and there is NO Cover specific RE with higher inuring level OR there is only one Cover in a given Contract) ***THEN***

**Step 1. Term ordering**

**Using S@R recoverable (remaining) compute total reinsurance loss () from all treaties with Index = index (do not take into account Occurrence Limits) and order S@Rs in descending order according to such computed. If some S@R’s have the same then order, say in descending order of and then in ascending order of S@R IDs (if necessary).**

**Step 2. Distribution of the Contract Payout to S@R’s**

**Allocate the total remaining Contract** payout (net loss)

to S@R’s starting from the first S@R from the ordered list. Define

The allocated loss should not exceed the

**. Maybe just take .**

Denote allocated location gross loss for location *l* as**.**

**Need to account for restrictions coming from the different nodes in a term tree. Approaches below work under the assumption # 8 , i.e. either all Covers have all Contract exposures as their children (all policies are blanket policies) OR there are non-overlapping restricted policy, considering blanket policy as restricted policy covering all S@Rs**

**Approach 1**

**Allocate Contract payout in the order in which S@R where organized based on the computed reinsurance. Each time deplete all parents of the given S@R by the allocated amount. Do not allocate further to the children if no payout is remaining.**

**Assume that S@R are in a specified order, i.e. for any )**

**Let is a set of all parents (in the term tree) of the S@R and let be the running recoverable of the of the Parent of the S@R .**

***FOR* ( every S@R *l*) *DO***

***(*Allocated Contract (or part of the Contract) payout to S@R l))**

***FOR* () *DO***

***ENDO p***

***ENDO l***

**Approach 2**

**For each node order direct children nodes in descending order of the total RE loss from all S@R’s covered by the child and allocate recoverable in this order, making sure that allocated loss doesn’t exceed recoverable of the child computed on the way up the tree. (Max Deductible?).**

**Step 3. Compute Reinsurance Loss.**

***FOR* ( every S@R *l* ) *DO***

***END l***

***FOR* (*r* from 1 to ) *DO (inuring priority loop)***

***FOR* (every S@R *l*) *DO***

***END l***

***FOR* (*t* from 1 to) *DO (treaty loop for inuring level r)***

***FOR* ( every S@R *l*) *DO***

***END l***

***,* hereis a set off all S@R’s from all Contracts covered by treaty *t***

***FOR* (for every S@R *l*) *DO***

***END l (end S@R loop)***

***END t (end treaty loop)***

***END r (end inuring priority loop)***

**(update Contract payout)**

***FOR* (every S@R *l*) *DO (total contract RE loss)***

***END l***

**Also may need to update all intermediate nodes of the term tree by aggregating from nodes children and netting that out of the recoverable for that node. This will be desirable if there is a location level treaty with inuring priority higher than that of the Cover level treaty.**

***ELSE IF*** (Index corresponds to Cover *p*) ***THEN***

***FOR* (*r* from 1 to ) *DO (inuring priority loop)***

***FOR* (*t* from 1 to) *DO (treaty loop for inuring level r)***

***,* hereis a set off all Covers from all Contracts covered by treaty**

***END t (end treaty loop)***

***END r (end inuring priority loop)***

***(update Cover payout)***

***(update Contract payout)***

***ELSE IF*** (Index corresponds to Contract and there is NO Cover specific RE with higher inuring level OR there is only one Cover, it is possible that there are S@R RE with higher inuring level) ***THEN***

***FOR* (*r* from 1 to ) *DO (inuring priority loop)***

***FOR* (*t* from 1 to) *DO (treaty loop for inuring level r)***

***END t (end treaty loop)***

***END r (end inuring priority loop)***

***(update Contract payout by subtracting Contract reinsurance loss)***

***ELSE IF*** (Index corresponds to Contract and there exists Cover specific RE (there is more than one Cover) with higher inuring level) ***THEN***

***(In this case need to allocate net loss back to Covers)***

***CASE 1* *Each Cover has all of the nodes of the term tree as their children***

***FOR* (every Cover *p* ) *DO***

***ENDO p***

***FOR* (*r* from 1 to ) *DO (inuring priority loop)***

**Translate attachment points (), limits ( ) directly to Cover level. See Appendix for details of the algorithm. Translated treaty Share () is equal to .**

***FOR* (every Cover *p* ) *DO***

***ENDO p***

***FOR* (*t* from 1 to) *DO (treaty loop for inuring level r)***

***FOR* (every Cover *p* ) *DO***

***ENDO p***

***FOR* (every Cover *p* ) *DO***

***ENDO p***

***END t (end treaty loop)***

***END r (end inuring priority loop)***

***FOR* (every Cover *p* ) *DO***

***(update Cover payout (net))***

***ENDO p***

***(update Contract payout (net))***

***END Case 1***

***CASE 2* *Each Cover has non-overlapping set of the children nodes of the term tree***

**The same as *CASE 1* except very slightly different algorithm for translating treaty attachment point, limit and Share to the Cover level.**

**Align attachment point of the lowest attaching Cover for each set of Covers sharing the same subjects. Allocate attachment points and limits of the treaties following methodology in Case 1.**

**Remark. The same approach of translating treaty attachment points and limits could be applied in cases when CAT treaty inures to the benefit of the Contract or Cover level Treaty**

***END Case 2***

***ENDIF***

# ****Consistency requirements****

* **Adding higher attaching location level treaty or treaty with the higher inuring priority could change losses to the existing lower attaching treaties or treaties at lower inuring priorities. Could be resolved by performing optimization by inuring priority. But this is more computationally intensive, since requires larger number of allocations of Cover/Contract net losses back to location level and sorting of locations. Also it is important to net all the intermediate nodes of the term tree. This even more computationally intensive if there are Cover level treaties/FACs**
* **Proportional allocation of the occurrence limit, though relatively easy computationally doesn’t necessarily guarantee the maximization of the FAC/Treaty recovery**

# ****Appendix.****

## Translating attachment points and limits of the Contract level treaties to the Cover level, assuming all Covers (layers) have all nodes of the term tree as their children.

### Notations

= attachment point of Cover

= limit of Cover

= Share of Cover

= attachment point of Treaty w.r.t Contract Payout

= limit of Treaty w.r.t Contract Payout

= Share of Treaty

### Algorithm

Sort and in ascending order. Create layers as shown in Fig.1. Denote the Layers as .

Bound5

Layer4

Cover 1

Bound2

Bound3

Bound1

Layer2

Layer1

Cover 2

Cover 3

Layer3

Layer5

Bound4

Bound0

**Fig 2. Layers of Covers on the gray box of the recoverable from the root node of a term tree shifted by the attachment point of the lowest attaching Cover**

**FOR** (each Layer *l*) ***DO***

***,***

where is a set of all Covers such that

and

***ENDO l***

For a given inuring priority

**FOR** (each Treaty *t*) ***DO***

*l* = 1

***DO WHILE*** ()

***END WHILE***

***FOR*** (each Cover ) ***DO***

***END DO***

***FOR*** (each Cover such that) ***DO***

***END DO***

***FOR*** (each Cover such that) ***DO***

(treaty doesn’t attach)

***END DO***

***DO WHILE*** ()

***END WHILE***

***FOR*** (each Cover) ***DO***

***END DO***

***FOR*** (each Cover such that) ***DO***

***END DO***

## Translating attachment points and limits of the Contract level treaties to the Cover level, If there are several non-overlapping Cover “towers”, i.e. groups of Covers that either share the same subjects or have non-overlapping subjects. Let *N* be the number of such “towers”. Align them at the lowest attaching Cover of each of them.

Bound2

Bound3

Bound1

Bound4

Cover 2

Cover 2,1

Layer2

Layer1

Cover 1,2

Cover 1,3

Layer3

Layer5

Cover 2,2

Cover 1,1

Layer4

Bound5

Bound0

**Fig 3. Layers of Covers on the gray box of recoverable from the root nodes of a non-overlapping term trees shifted by the attachment point of the lowest attaching Cover for each “tower”**

The methodology exactly follows the one described above with some modification.

**FOR** (each Layer *l*) ***DO***

***,*** where the firstsum is over the different “towers” and is a set of all Covers such that

and

***ENDO l***

In what follows the second index after Cover index stands for the tower number, e.g. is the attachment point of cover C in “tower” n.

For a given inuring priority

**FOR** (each Treaty *t*) ***DO***

*l* = 1

***DO WHILE*** ()

***END WHILE***

***FOR*** (each Cover ) ***DO***

***END DO***

***FOR*** (each Cover such that) ***DO***

***END DO***

***FOR*** (each Cover such that) ***DO***

(treaty doesn’t attach)

***END DO***

***DO WHILE*** ()

***END WHILE***

***FOR*** (each Cover) ***DO***

***END DO***

***FOR*** (each Cover such that ) ***DO***

***END DO***

# Future Enhancements

|  |  |  |
| --- | --- | --- |
| **No.** | **Enhancement** | **Reason for deferral** |
| 1. | Less computationally intensive but still acceptable approach for the case when there are Cover specific treaties |  |
| 2. |  |  |

# Open Issues

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **No.** | **Issue** | **Owner** | **Status** | **Create Date** | **Last Update Date** |
| 1 | Specifying per-risk treaties in CDL |  |  |  |  |
| 2 |  |  |  |  |  |

# Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Date** | **Version** | **Description** | **Author** |
|  | 1 | Original version | Bronislava Sigal |